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Alpha 1222161

SOLAR/1014-79/03

Monthly Performance Report

FEB 20 1980

HEI WAI WONG

MARCH 1979

U.S. Department of Energy

National Solar Heating and Cooling Demonstration Program

National Solar Data Program

4255

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MONTHLY PERFORMANCE REPORT

HEI WAI WONG

MARCH 1979

I. SYSTEM DESCRIPTION

The Hei Wai Wong site is a four-story multifamily housing complex in Honolulu, Hawaii. Solar energy is used for preheating domestic hot water (DHW) and laundry service hot water. The solar energy system comprises three distinct, essentially identical systems, only one of which is instrumented for performance evaluation. The instrumented system supplies preheated hot water to six apartment units and to the laundry of the housing complex. The system has an array of flat-plate collectors with a gross area of 807 square feet. The array faces south at an angle of 24 degrees to the horizontal. Water is the transfer medium that delivers solar energy from the collector array to storage and to the hot water loads. Solar energy is stored on the roof in a 1230-gallon storage tank. When solar energy is insufficient to satisfy the hot water loads, auxiliary water heating for each apartment is provided by electrical heating elements in individual 30-gallon DHW tanks. Auxiliary heating of hot water in the laundry is provided by a gas heater in the 85-gallon hot water tank. The system, shown schematically in Figure 1, has two modes of solar operation.

Mode 1 - Collector-to-Storage: This mode activates when a sufficient temperature difference exists between the collector surface temperature and the bottom of storage to activate a thermosiphon flow between collector and storage. The flow continues as long as the temperature difference is great enough to maintain the effect.

Mode 2 - Storage-to-Load: This mode activates when there is a demand for hot water replenishment from either the individual DHW tanks or the laundry tank. The system is pressurized by the city water system.

II. PERFORMANCE EVALUATION

INTRODUCTION

The site was occupied in March, and the solar energy system operated continuously during the month. Solar energy satisfied 94 percent of the DHW requirements. The solar energy system provided electrical energy savings of 8.5 million Btu and fossil fuel energy savings of 5.0 million Btu.

WEATHER CONDITIONS

During the month, total incident solar energy on the collector array was 46.8 million Btu for a daily average of 1871 Btu per square foot. This was above

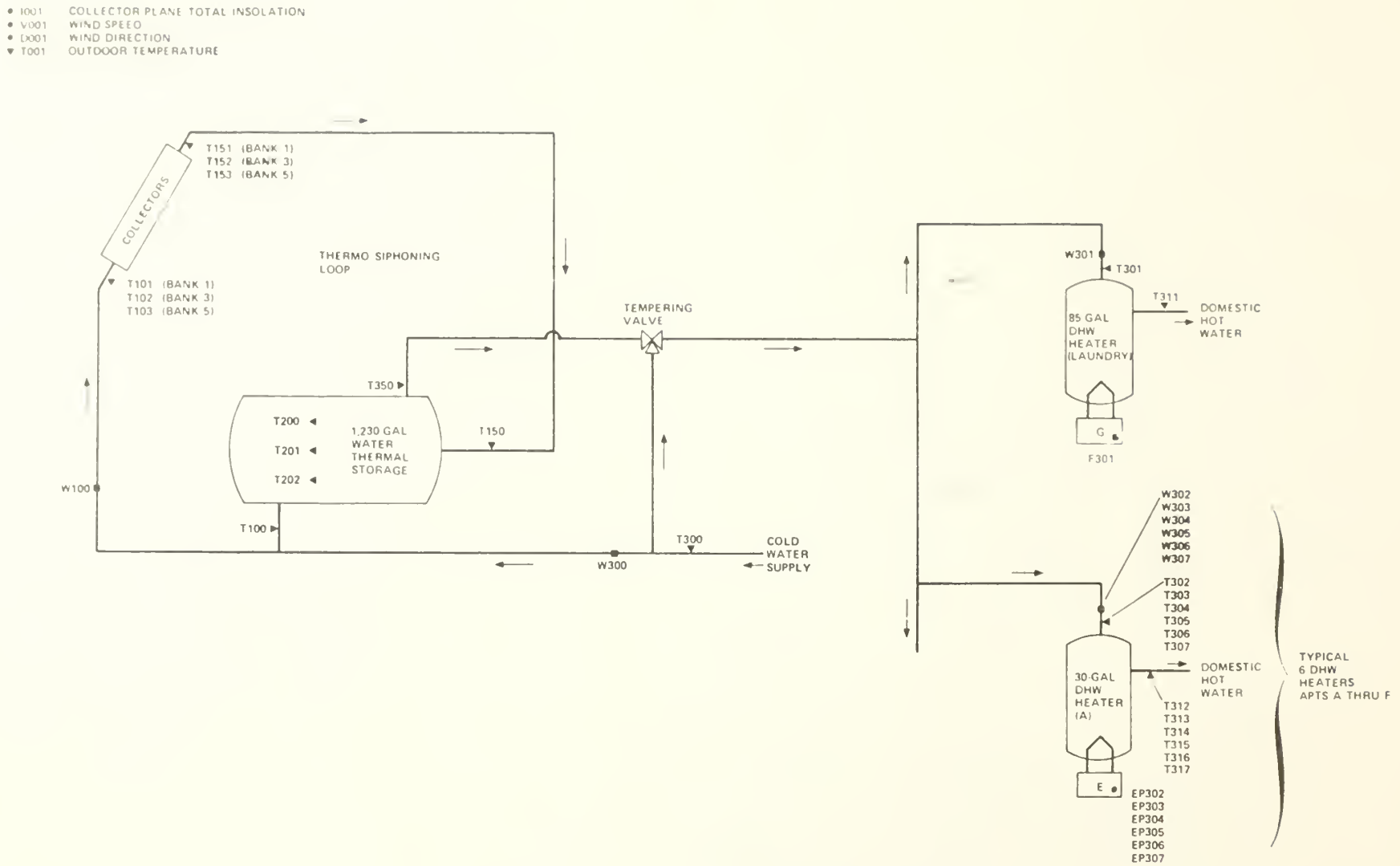

Figure 1. HEI WAI WONG SOLAR ENERGY SYSTEM SCHEMATIC

the estimated average daily solar radiation for this geographical area during March of 1721 Btu per square foot for a south-facing plane with a tilt of 24 degrees to the horizontal. The average ambient temperature during March was 73°F and was equal to the long-term average for March.

THERMAL PERFORMANCE

System - During March the solar energy system performed better than expected. The expected performance was determined from a modified f-chart analysis using measured weather and subsystem loads as inputs. Solar energy collected was 17.8 million Btu versus an estimated 10.6 million Btu. Solar energy used by the system was estimated by assuming that all energy collected would be applied to the load. Actual solar energy used was 11.5 million Btu. System total solar fraction was 94 percent versus an estimated 87 percent.

Collector - The total incident solar radiation on the collector array for the month of March was 46.8 million Btu. Since this is a thermosiphon system, the insolation available during the period the collector loop was operating also amounted to 46.8 million Btu. The total collected solar energy for the month of March was 17.8 million Btu, resulting in a collector array efficiency of 38 percent, based on total incident insolation. Solar energy delivered from the collector array to storage was 17.8 million Btu. The collector loop had no operating energy requirements.

Storage - Solar energy delivered to storage was 17.8 million Btu. There were 11.5 million Btu delivered from storage to the DHW subsystem. Energy loss from storage was 6.3 million Btu. This loss represented 35 percent of the energy delivered to storage. The storage efficiency was 65 percent: This is calculated as the ratio of the sum of the energy removed from storage and the change in stored energy, to the energy delivered to storage. The average storage temperature for the month was 136°F.

DHW Load - The DHW subsystem consumed 11.5 million Btu of solar energy and 0.72 million Btu of auxiliary electrical energy to satisfy a hot water load of 12.2 million Btu. The solar fraction of this load was 94 percent. There were no operating energy requirements. Solar support of the DHW subsystem in March resulted in an electrical energy savings of 8.5 million Btu and a fossil fuel energy savings of 5.0 million Btu. A daily average of 543 gallons of DHW was consumed at an average temperature of 154°F delivered from the storage tank.

OBSERVATIONS

The wind speed sensor stopped operating in March; therefore, the March wind speed data presented is invalid. Since the derivation of wind direction is based in part on wind speed, the wind direction data is also invalid.

ENERGY SAVINGS

The solar energy system provided a total electrical and fossil fuel energy savings of 13.5 million Btu.

III. ACTION STATUS

Boeing plans to investigate the wind speed sensor operation during a June site visit.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: HEI WAI WONG HONOLULU, HAWAII SOLAR/1014-79/03
REPORT PERIOD: MARCH,1979

SITE/SYSTEM DESCRIPTION:
THE INSTRUMENTED SOLAR ENERGY SYSTEM AT HEI WAI WONG PROVIDES FOR PREHEATING OF DOMESTIC HOT WATER FOR 6 APARTMENT UNITS AND LAUNDRY SERVICE HOT WATER FOR THE 4 STORY APARTMENT COMPLEX.
WATER STORAGE IS LOCATED HIGHER THAN THE SOLAR COLLECTORS. THIS ALLOWS FOR WATER PRESSURE AND THERMOSIPHONING TO TRANSPORT THE WATER THROUGH THE COLLECTOR/STORAGE CIRCUIT. HOT WATER (DHW AND LAUNDRY SERVICE HW) FLOW TO THE BUILDING IS GRAVITY FED FROM THE ROOFTOP MOUNTED STORAGE TANK.

GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	46.822	MILLION BTU
	57991	BTU/SQ.FT.
COLLECTED SOLAR ENERGY	17.795	MILLION BTU
	22040	BTU/SQ.FT.
AVERAGE AMBIENT TEMPERATURE	73	DEGREES F
AVERAGE BUILDING TEMPERATURE	N.A.	DEGREES F
DOSS SOLAR CONVERSION EFFICIENCY	0.25	
DOSS OPERATING ENERGY	N.A.	MILLION BTU
TOTAL SYSTEM OPERATING ENERGY	N.A.	MILLION BTU
TOTAL ENERGY CONSUMED	18.516	MILLION BTU

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING	SYSTEM TOTAL	
LOAD	12.238	N.A.	N.A.	12.238	MILLION BTU
SOLAR FRACTION	94	N.A.	N.A.	94	PERCENT
SOLAR ENERGY USED	11.516	N.A.	N.A.	11.516	MILLION BTU
OPERATING ENERGY	N.A.	N.A.	N.A.	N.A.	MILLION BTU
AUX. THERMAL ENERGY	0.721	N.A.	N.A.	0.721	MILLION BTU
AUX. ELECTRIC FUEL	0.721	N.A.	N.A.	0.721	MILLION BTU
AUX. FOSSIL FUEL	0.000	N.A.	N.A.	0.000	MILLION BTU
ELECTRICAL SAVINGS	8.487	N.A.	N.A.	8.487	MILLION BTU
FOSSIL SAVINGS	5.049	N.A.	N.A.	5.049	MILLION BTU

SYSTEM PERFORMANCE FACTOR: 5.095

* DENOTES UNAVAILABLE DATA
@ DENOTES NULL DATA
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT OF THE NATIONAL SOLAR DATA PROGRAM,FEBRUARY 28,1978. SOLAR/0004-78/18

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SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: HEI WAI WONG HONOLULU, HAWAII SOLAR/1014-79/03
REPORT PERIOD: MARCH,1979

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GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	49.397 GIGA JOULES
	658543 KJ/SQ.M.
COLLECTED SOLAR ENERGY	18.774 GIGA JOULES
	250283 KJ/SQ.M.
AVERAGE AMBIENT TEMPERATURE	23 DEGREES C
AVERAGE BUILDING TEMPERATURE	N.A. DEGREES C
DOSS SOLAR CONVERSION EFFICIENCY	0.25
DOSS OPERATING ENERGY	N.A. GIGA JOULES
TOTAL SYSTEM OPERATING ENERGY	N.A. GIGA JOULES
TOTAL ENERGY CONSUMED	19.535 GIGA JOULES

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING	SYSTEM TOTAL
LOAD	12.911	N.A.	N.A.	12.911 GIGA JOULES
SOLAR FRACTION	94	N.A.	N.A.	94 PERCENT
SOLAR ENERGY USED	12.150	N.A.	N.A.	12.150 GIGA JOULES
OPERATING ENERGY	N.A.	N.A.	N.A.	N.A. GIGA JOULES
AUX. THERMAL ENG	0.761	N.A.	N.A.	0.761 GIGA JOULES
AUX. ELECTRIC FUEL	0.761	N.A.	N.A.	0.761 GIGA JOULES
AUX. FOSSIL FUEL	0.000	N.A.	N.A.	0.000 GIGA JOULES
ELECTRICAL SAVINGS	8.954	N.A.	N.A.	8.954 GIGA JOULES
FOSSIL SAVINGS	5.327	N.A.	N.A.	5.327 GIGA JOULES

SYSTEM PERFORMANCE FACTOR: 5.095

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REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT OF THE NATIONAL SOLAR DATA PROGRAM,FEBRUARY 28,1978. SOLAR/0004-78/18

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SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENERGY COLLECTION AND STORAGE SUBSYSTEM (ECSS)

SITE: HEI WAI WONG HONOLULU, HAWAII
REPORT PERIOD: MARCH,1979

SOLAR/1014-79/03

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	AMBIENT TEMP DEG-F	ENERGY TO LOADS MILLION BTU	AUX THERMAL TO ECSS MILLION BTU	ECSS OPERATING ENERGY MILLION BTU	ECSS ENERGY REJECTED MILLION BTU	ECSS SOLAR CONVERSION EFFICIENCY
1	1.692	72	0.418	N	N	N	0.247
2	1.592	73	0.263	O	O	O	0.165
3	1.286	73	0.447	T	T	T	0.348
4	1.903	73	0.546				0.287
5	1.406	74	0.330	A	A	A	0.235
6	1.548	75	0.338	P	P	P	0.218
7	1.683	75	0.204	P	P	P	0.121
8	0.391	71	0.529	L	L	L	1.352
9	1.936	71	0.318	I	I	I	0.164
10	1.646	73	0.514	C	C	C	0.312
11	1.330	74	0.505	A	A	A	0.380
12	1.140	73	0.299	B	B	B	0.262
13	1.529	73	0.383	L	L	L	0.250
14	1.297	73	0.319	E	E	E	0.246
15	1.722	74	0.277				0.161
16	1.917	75	0.414				0.216
17	1.900	75	0.365				0.192
18	1.579	74	0.460				0.291
19	1.589	74	0.329				0.207
20	1.554	73	0.356				0.229
21	1.058	73	0.303				0.286
22	1.811	73	0.396				0.219
23	1.732	73	0.424				0.245
24	1.426	71	0.464				0.325
25	1.487	70	0.334				0.225
26	1.755	73	0.341				0.194
27	1.312	73	0.342				0.260
28	1.755	73	0.363				0.207
29	1.166	72	0.292				0.250
30	1.090	72	0.365				0.335
31	1.589	74	0.279				0.175
SUM	46.822	-	11.516	N.A.	N.A.	N.A.	-
AVG	1.510	73	0.371	N.A.	N.A.	N.A.	0.246
NBS ID	G001	N113			Q102		N111

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
COLLECTOR ARRAY PERFORMANCE

SITE: HEI WAI WONG HONOLULU, HAWAII SOLAR/1014-79/03
REPORT PERIOD: MARCH,1979

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	OPERATIONAL INCIDENT ENERGY MILLION BTU	COLLECTED SOLAR ENERGY MILLION BTU	DAYTIME AMBIENT TEMP DEG F	COLLECTOR ARRAY EFFICIENCY
1	1.692	1.692	0.555	78	0.330
2	1.592	1.592	0.498	78	0.313
3	1.286	1.286	0.386	79	0.300
4	1.903	1.903	0.746	79	0.392
5	1.406	1.406	0.390	81	0.277
6	1.548	1.548	0.589	83	0.380
7	1.683	1.683	0.600	82	0.356
8	0.391	0.391	0.068	69	0.173
9	1.936	1.936	0.701	76	0.362
10	1.646	1.646	0.590	76	0.359
11	1.330	1.330	0.454	79	0.342
12	1.140	1.140	0.412	79	0.362
13	1.529	1.529	0.538	77	0.352
14	1.297	1.297	0.440	77	0.339
15	1.722	1.722	0.629	79	0.365
16	1.917	1.917	0.745	78	0.388
17	1.900	1.900	0.702	80	0.370
18	1.579	1.579	0.585	83	0.373
19	1.585	1.585	0.568	79	0.358
20	1.554	1.554	0.526	77	0.339
21	1.058	1.058	0.273	75	0.258
22	1.811	1.811	0.691	77	0.382
23	1.732	1.732	0.626	76	0.362
24	1.426	1.426	0.695	77	0.490
25	1.487	1.487	0.954	78	0.641
26	1.755	1.755	1.018	79	0.580
27	1.312	1.312	0.445	78	0.339
28	1.755	1.755	0.653	79	0.372
29	1.168	1.168	0.528	77	0.452
30	1.090	1.090	0.570	78	0.523
31	1.589	1.589	0.608	80	0.383
SUM	46.822	46.822	17.795	-	-
AVG	1.510	1.510	0.574	78	0.380
NESID	C001		C100		N100

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

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SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
STORAGE PERFORMANCE

SITE: HEI WAI WONG HONOLULU, HAWAII SOLAR/1014-79/03
REPORT PERIOD: MARCH,1979

DAY OF MONTH	ENERGY TO STORAGE MILLION BTU	ENERGY FROM STORAGE MILLION BTU	CHANGE IN STORED ENERGY MILLION BTU	STORAGE AVERAGE TEMP DEG F	STORAGE EFFICIENCY
1	0.559	0.418	0.012	137	0.769
2	0.498	0.263	0.059	141	0.648
3	0.386	0.447	-0.108	137	0.878
4	0.746	0.546	0.037	135	0.782
5	0.390	0.330	-0.026	137	0.781
6	0.589	0.338	0.086	141	0.721
7	0.600	0.204	0.120	151	0.539
8	0.068	0.529	-0.478	131	0.761
9	0.701	0.318	0.216	117	0.762
10	0.590	0.514	-0.015	128	0.845
11	0.454	0.505	-0.049	125	1.004
12	0.412	0.299	0.006	121	0.741
13	0.538	0.383	0.070	124	0.842
14	0.440	0.319	-0.032	128	0.651
15	0.629	0.277	0.139	133	0.662
16	0.745	0.414	0.040	144	0.610
17	0.702	0.365	0.054	149	0.596
18	0.589	0.460	-0.067	149	0.667
19	0.568	0.329	-0.016	142	0.550
20	0.526	0.356	0.010	142	0.696
21	0.273	0.303	-0.132	133	0.625
22	0.691	0.396	0.077	135	0.685
23	0.626	0.424	0.009	138	0.691
24	0.699	0.464	-0.061	137	0.576
25	0.954	0.334	0.014	134	0.365
26	1.018	0.341	0.180	142	0.512
27	0.445	0.342	-0.137	143	0.460
28	0.653	0.363	0.045	141	0.624
29	0.528	0.292	-0.132	137	0.304
30	0.570	0.365	-0.041	127	0.567
31	0.608	0.279	0.090	132	0.606
SUM	17.795	11.516	-0.031	-	-
AVG	0.574	0.371	-0.001	136	0.645
NBS ID	G200	G201	G202		N108

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
HOT WATER SUBSYSTEM

SITE: HEI WAI WONG HONOLULU, HAWAII
REPORT PERIOD: MARCH,1979

SOLAR/1014-79/03

DAY OF MON.	HOT WATER LOAD MILLION BTU	SOLAR FR.OF LOAD PER CENT	SOLAR ENERGY USED MILLION BTU	OPER ENERGY MILLION BTU	AUX THERMAL USED MILLION BTU	AUX ELECT FUEL MILLION BTU	AUX FOSSIL FUEL MILLION BTU	ELECT ENERGY SAVINGS MILLION BTU	FOSSIL ENERGY SAVINGS MILLION BTU	SUP. WAT. TEMP DEG F	HOT WAT. TEMP DEG F	HOT WATER USED GAL
1	0.456	92	0.418	N	0.038	0.038	0.000	0.282	0.227	74	160	566
2	0.289	91	0.263	O	0.026	0.026	0.000	0.133	0.217	77	159	347
3	0.479	93	0.447	T	0.032	0.032	0.000	0.346	0.169	75	156	643
4	0.584	94	0.546		0.037	0.037	0.000	0.356	0.318	74	152	832
5	0.356	93	0.330	A	0.025	0.025	0.000	0.185	0.242	75	156	474
6	0.361	94	0.338	P	0.023	0.023	0.000	0.265	0.122	75	160	446
7	0.220	93	0.204	P	0.016	0.016	0.000	0.146	0.096	77	168	255
8	0.551	96	0.529	L	0.022	0.022	0.000	0.246	0.471	74	161	724
9	0.340	94	0.318	I	0.022	0.022	0.000	0.257	0.103	72	138	563
10	0.542	95	0.514	C	0.028	0.028	0.000	0.348	0.277	72	147	808
11	0.532	95	0.505	A	0.026	0.026	0.000	0.406	0.166	72	144	829
12	0.322	93	0.299	E	0.023	0.023	0.000	0.223	0.126	73	140	515
13	0.404	95	0.383	L	0.022	0.022	0.000	0.317	0.109	72	142	642
14	0.336	95	0.319	E	0.017	0.017	0.000	0.224	0.158	73	143	525
15	0.301	92	0.277		0.023	0.023	0.000	0.249	0.047	75	148	444
16	0.436	95	0.414		0.022	0.022	0.000	0.245	0.282	75	161	543
17	0.383	95	0.365		0.018	0.018	0.000	0.287	0.130	76	166	476
18	0.478	96	0.460		0.018	0.018	0.000	0.280	0.300	76	165	591
19	0.347	95	0.329		0.018	0.018	0.000	0.288	0.068	77	161	450
20	0.377	94	0.356		0.021	0.021	0.000	0.276	0.134	75	158	504
21	0.322	94	0.303		0.019	0.019	0.000	0.265	0.063	75	152	460
22	0.419	95	0.396		0.022	0.022	0.000	0.347	0.083	75	152	570
23	0.449	94	0.424		0.026	0.026	0.000	0.292	0.219	76	159	586
24	0.485	96	0.464		0.022	0.022	0.000	0.404	0.100	74	158	636
25	0.361	92	0.334		0.027	0.027	0.000	0.170	0.274	74	152	504
26	0.362	94	0.341		0.021	0.021	0.000	0.194	0.245	75	156	487
27	0.361	95	0.342		0.020	0.020	0.000	0.300	0.070	76	160	473
28	0.384	94	0.363		0.021	0.021	0.000	0.252	0.185	76	159	488
29	0.315	93	0.292		0.023	0.023	0.000	0.292	0.000	77	155	429
30	0.385	95	0.365		0.020	0.020	0.000	0.348	0.028	71	143	612
31	0.302	92	0.279		0.023	0.023	0.000	0.266	0.021	76	146	424
SUM	12.238	-	11.516	N.A.	0.721	0.721	0.000	8.487	5.049	-	-	16848
AVG	0.395	94	0.371	N.A.	0.023	0.023	0.000	0.274	0.163	75	154	543
NBS	Q302	N300	Q300	Q303	Q301	Q305	Q306	Q311	Q313	N305	N307	N308

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

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SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENVIRONMENTAL SUMMARY

SITE: HEI WAI WONG HONOLULU, HAWAII
REPORT PERIOD: MARCH,1979

SOLAR/1014-79/03

DAY OF MONTH	TOTAL INSOLATION BTU/SQ.FT	DIFFUSE INSOLATION BTU/SQ.FT	AMBIENT TEMPERATURE DEG F	DAYTIME AMBIENT TEMP DEG F	RELATIVE HUMIDITY PERCENT	WIND DIRECTION DEGREES	WIND SPEED M.P.H.
1	2096	N	72	78	N	228	2
2	1971	O	73	78	O	235	2
3	1893	T	73	79	T	0	1
4	2357		73	79		0	1
5	1742	A	74	81	A	0	0
6	1917	F	75	83	P	0	1
7	2084	P	75	82	P	0	1
8	485	L	71	69	L	218	3
9	2398	I	71	76	I	218	7
10	2038	C	73	76	C	220	2
11	1647	A	74	79	A	0	0
12	1411	E	73	79	B	0	0
13	1893	L	73	77	L	0	0
14	1606	E	73	77	E	0	0
15	2133		74	79		0	0
16	2374		75	78		0	0
17	2353		75	80		0	0
18	1955		74	83		0	0
19	1968		74	79		0	0
20	1925		73	77		0	0
21	1311		73	75		0	0
22	2243		73	77		0	0
23	2145		73	76		0	0
24	1767		71	77		0	0
25	1842		70	78		0	0
26	2174		73	79		0	0
27	1625		73	78		0	0
28	2173		73	79		0	0
29	1446		72	77		0	0
30	1350		72	78		0	0
31	1967		74	80		0	0
SUM	57991	N.A.	-	-	-	-	-
AVG	1871	N.A.	73	78	N.A.	0	1
NBS ID	0001		N113			N115	N114

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

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